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REMARKS

Claims 1-34 remain pending in the present application. Claims 1-5, 12, 14, 22-25, and 28 stand finally rejected under 35 U.S.C. §102(e) for anticipation by Tillmetz et al. U.S. Patent No. 6,410,175. Claims 6-9, 13, 20, 21, 26, 27 and 29 stand finally rejected under 35 U.S.C. §103(a) for obviousness in view of Tillmetz. Claim 11 stands finally rejected under 35 U.S.C. §103(a) for obviousness in view of the combination of Tillmetz with Narayanan et al. U.S. Patent No. 6,299,744. Claims 15, 30, 31 and 34 stand finally rejected under 35 U.S.C. §103(a) for obviousness in view of the combination of Tillmetz with Prakash et al. U.S. Patent No. 6,444,343. Claims 10, 16-19, 32 and 33 stand objected to as being dependent on a rejected base claim, but were indicated as being allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

As set forth in the applicants' Amendment and Request for Reconsideration dated May 27, 2003, supplemented on June 11, 2003, the applicants' Response After Final Rejection and Request for Reconsideration dated September 24, 2003, and the applicants' Response and Request for Reconsideration dated November 24, 2003, Tillmetz, the principal reference on which all of the final rejections were based, does not, and cannot,

qualify as a prior art reference against the claims of the present application because the present application is entitled to priority benefits from German Patent Application No. 19807876.5 (attached hereto at Appendix A-1), which has an effective filing date of February 25, 1998. The effective date of the Tillmetz patent, for prior art purposes, is its filing date of November 12, 1998.

In the July 24, 2003 Office Action, made final, applicants' claim of priority benefits from the German application was denied because, according to the Office Action, the applicants had not filed the requisite certified copy of the priority application required by 35 U.S.C. 119(b). (See July 24, 2003 Office Action at page 6). In their after-final response, applicants submitted a certified copy of German Application No. 19807876.5. An English translation (copy attached hereto at Appendix A-2) of the German priority application was submitted on September 24, 2003.

In the October 15, 2003 Advisory Action, the final rejections of claims 1-9, 11-14 and 20-29 in view of Tillmetz were maintained because, according to the Advisory Action, the foreign priority document (German Patent Application No. 19807876.5) failed to provide support for the claim limitation

"fuel stream comprising dimethyl ether" recited in independent claims 1 and 22. The Advisory Action stated, "Instead, the German priority document only teaches the use of liquid methanol or di- or trimethoxymethane as the fuel." (Advisory Action at page 2).

Applicants submit that the Advisory Action overlooked a portion of the disclosure of the German priority application here. Specifically, the German priority application does in fact disclose the use of dimethyl ether as a fuel:

The fuel cell system shown in the figure comprises a fuel cell 10, consisting of an anode chamber 12 and a cathode chamber 14, separated by a proton conducting membrane 16. A liquid coolant/fuel mixture is supplied to the anode chamber 12 by an anode feed line 18. **All substances which can be oxidized chemically and have the general structural formula $H-[CH_2O-]_n-Y$, with $1 \leq n \leq 5$ and $Y=H$ or $Y=CH_3$, can be used as fuel.** The fuel cell system in the illustrated design example is operated with liquid methanol as fuel and water as coolant. Even though only the use of water/methanol mixture will be described in the following, the extent of protection of this application should not be limited to this design example. Especially fluids or ionic or non-ionic water additives with favorable antifreeze properties can be considered as coolants.

Possible fuels are e.g. branched variants of the above general formula, such as, for example, di- or trimethoxymethane.

(English translation of German Application No. 19807876.5 at pages 3-4 (emphasis added); attached at Appendix A-2). Although the above-quoted paragraph specifically names methanol and di- and trimethoxymethane as examples of suitable oxidizable fuels, the paragraph also provides a structural formula that encompasses additional fuels, including dimethyl ether.

The structural formula has two variables: n and Y. There are specified possibilities for n and Y. The following table show the possible compounds specified by the formula:

n	Y	compound
n=1	Y=H	CH ₃ OH
n=1	Y=CH₃	CH₃OCH₃
n=2	Y=H	CH ₃ OCH ₂ OH
n=2	Y=CH ₃	CH ₃ OCH ₂ OCH ₃
n=3	Y=H	CH ₃ OCH ₂ OCH ₂ OH
n=3	Y=CH ₃	CH ₃ OCH ₂ OCH ₂ OCH ₃
n=4	Y=H	CH ₃ OCH ₂ OCH ₂ OCH ₂ OH
n=4	Y=CH ₃	CH ₃ OCH ₂ OCH ₂ OCH ₂ OCH ₃
n=5	Y=H	CH ₃ OCH ₂ OCH ₂ OCH ₂ OCH ₂ OH
n=5	Y=CH ₃	CH ₃ OCH ₂ OCH ₂ OCH ₂ OCH ₂ OCH ₃

That structural formula, $H-[CH_2O-]_n-Y$, corresponds to dimethyl ether (CH_3OCH_3) when $n=1$ and $Y=CH_3$, thereby providing explicit written support for the dimethyl ether limitation recited in the applicants' claims.

The Manual of Patent Examination Procedure states that a structural chemical formula provides the written description for a claim drawn to a single embodiment or species. See MPEP §2163, pages 2100-2167 (8th edition, first revision, February 2003). In discussing the examination of claims drawn to a single embodiment or species, the MPEP states:

(B) If the application does not describe an actual reduction to practice, determine whether the invention is complete as evidenced by a reduction to drawings or structural chemical formulas that are sufficiently detailed to show that applicant was in possession of the claimed invention as a whole.

Id.

The U.S. Court of Appeals for the Federal Circuit has also ruled that a structural formula can itself provide adequate written support for a claim limitation. In *Singh v. Brake*, 317 F.3d 1334, 65 USPQ2d 1641 (Fed. Cir. 2003; copy attached hereto

at Appendix B), the Federal Circuit held that the formula in Brake's priority document $((R)_r(GAXYCX)_n\text{-Gene*})_y$, where n is 0 or 1 to 4), provided a sufficient written description for a claim where $n = 0$. *Singh*, 317 F.3d at 1343 and n.5, 65 USPQ2d at 1647, note 5, and 1648. The court found that the formula only permitted 17 permutations of the GAXYCX sequence, not 9000+ as Singh had argued, and agreed with Brake that there were only two meaningful embodiments (when N is 1 to 4 and when N is 0). *Singh*, 317 F.3d at 1344, 65 USPQ2d at 1648. The Court also found that claim 5 of the priority application "discloses that N is 0 or 1 to 4, which is a clear 'blaze mark' providing *in ipsius verba* support for ' $N = 0$ ' in the count." *Singh*, 317 F.3d at 1344, 65 USPQ2d at 1649.

Similarly, the applicants' German priority application sets out the structural formula $H\text{-}[\text{CH}_2\text{O-}]_n\text{-Y}$, which corresponds to dimethyl ether when $n=1$ and $Y=\text{CH}_3$. This disclosure constitutes more than adequate support, if not *in ipsius verba* support, for the dimethyl ether limitation of the applicants' claims.

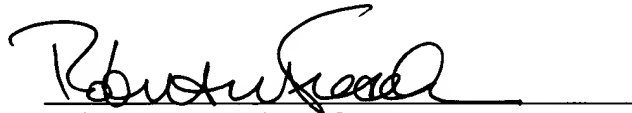
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In view of the foregoing remarks, applicants submit that claims 1-9, 11-15, 20-31 and 34 are allowable, in addition to

claims 10, 16-19, 32 and 33 already indicated as being allowable. The Examiner is invited to telephone the applicants' undersigned attorney at (312) 775-8202 if any unresolved matters remain.

Please charge any fees incurred in connection with this submission to Deposit Account No. 13-0017 in the name of McAndrews, Held & Malloy, Ltd.

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Bescheinigung

Die Daimler-Benz Aktiengesellschaft in Stuttgart/Deutschland hat eine Patentanmeldung unter der Bezeichnung

"Brennstoffzellensystem"

am 25. Februar 1998 beim Deutschen Patent- und Markenamt eingereicht.

Die Anmeldung ist auf die DaimlerChrysler AG in Stuttgart/Deutschland umgeschrieben worden.

Die angehefteten Stücke sind eine richtige und genaue Wiedergabe der ursprünglichen Unterlagen dieser Patentanmeldung.

Die Anmeldung hat im Deutschen Patent- und Markenamt vorläufig das Symbol H 01 M 8/04 der Internationalen Patentklassifikation erhalten.

München, den 3. Mai 1999

Deutsches Patent- und Markenamt

Der Präsident

Im Auftrag

Joost

Aktenzeichen: 198 07 876.5

Daimler-Benz-Aktiengesellschaft
Stuttgart

EP/VP - MH
13.02.1998

Zusammenfassung

Brennstoffzellensystem mit mindestens einer Brennstoffzelle, die einen Anodenraum und einen Kathodenraum aufweist, die durch eine protonenleitende Membran voneinander getrennt sind, mit einer Kathodenzuleitung zur Zufuhr von sauerstoffhaltigem Gas zum Kathodenraum, einer Anodenzuleitung zur Zufuhr eines flüssigen Kühlmittel/Brennstoff-Gemisches zum Anodenraum, wobei der Anodenraum in einem einen Gasabscheider und eine Pumpe umfassenden Anodenkreislauf angeordnet ist und eine Kühlung des im Anodenkreislauf zirkulierenden Kühlmittel/Brennstoff-Gemisches durch die Brennstoffzelle erfolgt, die auf einen Betrieb mit Wasserdurchbruch von dem Anodenraum in den Kathodenraum ausgelegt ist. Durch die somit erzielte Verdampfungskühlung in der Brennstoffzelle erfolgt eine Kühlung des Kühlmittel/Brennstoff-Gemisches bei einer sich in der Brennstoffzelle in Abhängigkeit von den Membraneigenschaften und der Drehzahl der Pumpe einstellenden stationären Betriebstemperatur, so daß im Anodenkreislauf selbst kein zusätzlicher Kühler mehr notwendig ist.

Anode:

Kathode:

Brennstoff:

Kühlmittel:

Gas:

Pumpe:

Gasabscheider:

Membran:

Stationäre Betriebstemperatur:

Drehzahl:



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Brennstoffzellensystem

Die Erfindung betrifft ein Brennstoffzellensystem mit einer Brennstoffzelle, die einen Anodenraum und einen Kathodenraum aufweist, die durch eine protonenleitende Membran voneinander getrennt sind.

Zur Zeit ist zur Verstromung von flüssigen Energieträgern in einem Brennstoffzellensystem mit Protonenaustauschermembran (PEM-Brennstoffzelle) weltweit schwerpunktmäßig die Reformierung von Methanol in einem Gaserzeugungssystem vorgesehen. Dabei wird ein Wasser/Methanol-Gemisch verdampft und in einem Reformier zu Wasserstoff, Kohlendioxid und Kohlenmonoxid umgesetzt. Verdampfung und Reformierung sind hinsichtlich des energetischen Umsatzes sehr aufwendig. Dies hat Wirkungsgradverluste für das Gesamtsystem zur Folge. Darüber hinaus sind Gasaufbereitungsschritte zur Reinigung des Reformierungsgases notwendig. Das gereinigte Gas wird an dem PEM-Brennstoffzellensystem zugeführt. Des weiteren muß ein Kühler zur Kühlung des in dem Anodenkreislauf umlaufenden Kühlmittel/Brennstoff-Gemisches vorgesehen sein.

Ein weiteres Problem stellt der Wassereinsatz für die Reformierung dar. Das auf der Kathodenseite anfallende Produktwasser reicht zur Deckung des Wasserhaushaltes nicht aus. Hierdurch wird ein separater Wassertank notwendig.

Aus der US-PS 5 599 638 ist ein Brennstoffzellensystem bekannt, das einen aus mehreren miteinander verschalteten Brennstoffzellen bestehenden sogenannten Stack aufweist. Der Anodenraum des Stacks bildet Bestandteil eines Anodenkreislaufes, umfassend

einen Wärmetauscher zum Kühlen des vom Anodenausgang abgeleiteten, Kohlendioxid enthaltenden Kühlmittel/Brennstoff-Gemisches, einen Zirkulationstank, in welchem das gekühlte Gemisch einem neu zugeleiteten Kühlmittel/Brennstoff-Gemisch zugesetzt wird, einem in den Zirkulationstank integrierten Gasabscheider zum Abtrennen von Kohlendioxid, und eine Pumpe zum Zuleiten des Kühlmittel/Brennstoff-Gemisches aus dem Zirkulationstank in den Anodenraum über eine entsprechende Zuleitung. Das Sauerstoff und Wasserdampf umfassende Kathodenabgas des bekannten Brennstoffzellensystems wird durch einen Wasserabscheider geleitet, wobei das abgeschiedene Wasser dem Anodenkreislauf zuzuführenden Kühlmittel/Brennstoff-Gemisch zugeleitet und ein Teil des verbleibenden Sauerstoffes in die Oxidationsmittelzufuhr für den Kathodenraum geleitet wird.

Ausgehend hiervon liegt der Erfindung die Aufgabe zugrunde, ein im Aufbau vereinfachtes und kompaktes Brennstoffzellensystem mit protonenleitender Membran mit verbessertem Gesamtwirkungsgrad bereitzustellen.

Zur Lösung dieser Aufgabe wird erfindungsgemäß ein Brennstoffzellensystem mit den Merkmalen des Anspruchs 1 vorgeschlagen. Durch den erfindungsgemäßen Betrieb der Brennstoffzelle mit Wasserdurchbruch von dem Anodenraum in den Kathodenraum erfolgt in der Brennstoffzelle bei Aufnahme des Wassers durch die heiße Luft des Kathodenraums eine Verdampfungskühlung, die erfindungsgemäß zur Kühlung des Anodenkreislaufes genutzt wird. Durch diese Maßnahme kann der Kühler, der sonst im Anodenkreislauf vorgesehen sein muß, eingespart werden.

Weitere vorteilhafte Ausgestaltungen der Erfindung sind in den Unteransprüchen beschrieben.

Vorteilhafterweise wird die Brennstoffzelle in einem Gleichgewicht der Wärmebilanz betrieben, d.h. die Brennstoffzelle wird stationär bei einer Temperatur betrieben, die zum einen von den Eigenschaften der protonenleitenden Membran abhängt und zum an-

deren durch die Drehzahl der Flüssigkeitspumpe einstellbar ist. Je nach Lastpunkt beträgt die Temperatur des stationären Betriebs zwischen 90 und 110°C. Die Einstellung einer stationären Betriebstemperatur ist von entscheidender Bedeutung zur Wirkungsgradsteigerung der Brennstoffzelle bzw. des aus mehreren Brennstoffzellen gebildeten Stacks, da nunmehr ein isothermer Betrieb des Stacks möglich ist, d.h. Temperaturdifferenzen über die Stacklänge, wie sie bei bekannten Systemen in einer Größenordnung von ca. 10°C üblich sind, treten nicht mehr bzw. nur unwesentlich auf.

Die erfindungsgemäße Verdampfungskühlung in der Brennstoffzelle hat darüber hinaus den Vorteil, daß der Massenstrom der trockenen Luft auf das 1,5 bis 2-fache angehoben wird, womit eine Steigerung der Expanderleistung um den gleichen Faktor verbunden ist. Damit ist auch eine Energieeinsparung für die Luftversorgung im Vollastbetrieb verbunden.

Vorteilhafterweise ist ein Luftkühler hinter dem Expander vorgesehen, der in thermischer Kopplung mit dem Fahrzeugkühler steht und der zum Auskondensieren von Wasser zum Erreichen einer positiven Wasserbilanz im System dient.

Die Erfindung wird anhand eines Ausführungsbeispiels in der Zeichnung schematisch dargestellt und im folgenden unter Bezugnahme auf die Zeichnung näher erläutert.

Die einzige Figur zeigt in schematischer Darstellung den Prinzipaufbau eines erfindungsgemäßen Brennstoffzellensystems.

Das in der Figur dargestellte Brennstoffzellensystem umfaßt eine Brennstoffzelle 10, die aus einem Anodenraum 12 und einem Kathodenraum 14 besteht, die durch eine protonenleitende Membran 16 voneinander getrennt sind. Über eine Anodenzuleitung 18 wird dem Anodenraum 12 ein flüssiges Kühlmittel/Brennstoff-Gemisch zugeführt. Als Brennstoff kann hierbei jede elektrochemisch oxidierbare Substanz mit der allgemeinen Strukturformel

$H - [-CH_2O-]_n - Y$ mit $1 \leq n \leq 5$ und $Y=H$ oder $Y=CH_3$ verwendet werden. Das Brennstoffzellensystem des dargestellten Ausführungsbeispiels wird mit flüssigem Methanol als Brennstoff und Wasser als Kühlmittel betrieben. Obwohl im folgenden nur noch die Verwendung eines Wasser/Methanol-Gemisches beschrieben wird, soll der Schutzbereich dieser Anmeldung jedoch nicht auf dieses Ausführungsbeispiel beschränkt sein. Als Kühlmittel kommen insbesondere auch Flüssigkeiten oder ionische beziehungsweise nicht-ionische Zusätze zum Wasser mit guten Frostschutzeigenschaften in Frage. Bei den möglichen Brennstoffen handelt es sich beispielsweise um verzweigte Varianten obiger allgemeiner Formel, wie zum Beispiel Di- oder Trimethoxymethan.

In den Kathodenraum 14 wird über eine Kathodenzuleitung 20 ein sauerstoffhaltiges Gas geleitet. Gemäß dem dargestellten Ausführungsbeispiel wird hierzu Umgebungsluft verwendet. In der Brennstoffzelle 10 wird der Brennstoff an der Anode oxidiert, der Luftsauerstoff an der Kathode reduziert. Hierzu wird die protonenleitende Membran 16 auf den entsprechenden Oberflächen mit geeigneten Katalysatoren beschichtet. Von der Anodenseite können nun Protonen durch die protonenleitende Membran 16 wandern und sich an der Kathodenseite mit den Sauerstoffionen zu Wasser verbinden. Bei dieser elektrochemischen Reaktion entsteht zwischen den beiden Elektroden eine Spannung. Durch Parallel- bzw. Hintereinanderschaltung vieler solcher Zellen zu einem sogenannten Stack können Spannungen und Stromstärken erreicht werden, die zum Antrieb eines Fahrzeugs ausreichen.

Als Produkt entsteht am Anodenausgang ein mit Wasser und Methanol angereichertes Kohlendioxidgas. Dieses Flüssigkeits-/Gasgemisch wird über eine Anodenableitung 22 aus dem Anodenraum 12 abgeführt. Die Restsauerstoff und Wasserdampf enthaltende Kathodenabluft wird über eine Kathodenabgasleitung 24 abgeführt. Um einen guten Wirkungsgrad zu erhalten, wird die Umgebungsluft im Kathodenraum 14 mit Überdruck bereitgestellt. Hierzu ist in der Kathodenzuleitung 20 ein mit Hilfe eines Elektromotors 26 angetriebener Kompressor 28 mit nachgeordnetem

Luftladekühler 29 angeordnet, der den gewünschten Luftmassenstrom ansaugt und auf das erforderliche Druckniveau verdichtet. Beim Betrieb mit Umgebungsluft wird außerdem vorzugsweise im Eintrittsbereich der Kathodenzuleitung 20 stromauf des Kompressors 28 ein Luftfilter 30 vorgesehen. Ein Teil der für die Komprimierung der Umgebungsluft benötigten Energie kann mit Hilfe eines in der Kathodenabgasleitung 24 angeordneten Expanders 32 zurückgewonnen werden. Vorzugsweise sind der Kompressor 28, der Expander 32 und der Elektromotor 26 auf einer gemeinsamen Welle angeordnet. Die Regelung der Brennstoffzellenleistung erfolgt durch Steuerung oder Regelung der Kompressordrehzahl und damit des zur Verfügung stehenden Luftmassenstromes.

Auf der Anodenseite wird das Wasser/Methanol-Gemisch mit Hilfe einer Pumpe 34 bei einem vorgegebenen Druck zirkuliert, um an der Anode ständig ein Überangebot an Brennstoff zu gewährleisten. Das Verhältnis von Wasser zu Methanol in der Anodenzuleitung 18 wird mit Hilfe eines Sensors 36 eingestellt, der die Methanolkonzentration in der Anodenzuleitung 18 mißt. In Abhängigkeit von diesem Sensorsignal erfolgt dann eine Konzentrationsregelung für das Wasser/Methanol-Gemisch, wobei das flüssige Methanol aus einem Methanoltank 38 über eine Methanolzuführungsleitung 40 zugeführt und mit Hilfe einer nicht näher gezeigten Einspritzdüse 44 in die Anodenzuleitung 18 eingespritzt wird. Der Einspritzdruck wird durch eine in der Methanolzuführungsleitung 40 angeordnete Einspritzpumpe 42 erzeugt. Dem Anodenraum 12 wird somit ständig ein Wasser/Methanol-Gemisch mit konstanter Methanolkonzentration zugeführt.

Aus dem durch die Anodenableitung 22 abgeführten Flüssigkeits-/Gasgemisch muß nun das mit Methanol- und Wasserdampf angereicherte Kohlendioxid abgetrennt werden. Dazu wird das Flüssigkeits-/Gasgemisch über die Anodenableitung 22 einem Gasabscheider 52 zugeführt, in welchem das Kohlendioxid abgetrennt wird. Das in dem Gasabscheider 52 verbleibende Wasser/Methanol-Gemisch wird über eine Leitung 54 in die Anodenzuleitung 18 zurückgeführt.

Das in dem Gasabscheider 52 abgetrennte feuchte Kohlendioxidgas wird in einem Kühler 56 auf eine möglichst niedrige Temperatur abgekühlt und in einem nachgeordneten Wasserabscheider 58 wird weiteres Methanol und Wasser auskondensiert. Das verbleibende trockene Kohlendioxid mit einem geringen Gehalt an Restmethanol wird über eine Leitung 60 der Kathodenabgasleitung 24 zugeführt, wo es mit der sauerstoffreichen Kathodenabluft vermischt wird. Um möglichst viel Wasser aus der Kathodenabluft abzutrennen, sind hinter dem Ausgang des Kathodenraums 14 ein erster Wasserabscheider 59 und stromab des Expanders 32 ein weiterer Wasserabscheider 61 vorgesehen. Der Expander 32 dient dabei als kompakte Kondensationsturbine, an deren Ausgang wiederum ein Teil des Wasserdampfes auskondensiert. Das in den Wasserabscheidern 59, 61 gesammelte Wasser wird anschließend über eine Rückspeiseleitung 64 mit integrierter Rückspeisepumpe 62 in einen Sammel- und Reinigungsbehälter 50 eines Nebenzweiges 48, 66 des Anodenkreislaufes zurückgeleitet. Bei dem Sammel- und Reinigungsbehälter 50 handelt es sich insbesondere um einen Ionentauscher.

In dem Anodenkreislauf ist stromab des Anodenausgangs in der Anodenableitung 22 eine Abzweigungsleitung 48 vorgesehen, die zu dem Sammel- und Reinigungsbehälter 50 führt. Der Ausgang des Sammel- und Reinigungsbehälters 50 ist über eine Leitung 66 mit integriertem Ventil 68 stromauf des Gasabscheiders 52 wieder mit der Anodenableitung 22 verbunden. Der Sammel- und Reinigungsbehälter 50 dient zum Sammeln und Reinigen des von dem Anodenraum 12 kommenden Wasser/Methanol-Gemisches und des in dem Wasserabscheider 58 abgeschiedenen Wassers sowie des über die Rückspeiseleitung 64 in den Anodenkreislauf zurückgeleiteten kathodenseitig angefallenen Produktwassers. Das Ventil 68 dient zum einen zur Verhinderung eines Rückflusses aus der Anodenableitung 22 in die Leitung 66, zum anderen zur Erstellung des Anteils des Gemisches aus der Anodenableitung 22, der durch den Sammel- und Reinigungsbehälter geleitet werden soll.

Erfindungsgemäß wird die Brennstoffzelle 10 mit Wasserdurchbruch von dem Anodenraum 12 in den Kathodenraum 14 betrieben. Das auf diese Weise in den Kathodenraum 14 gelangende flüssige Wasser wird von der über die Kathodenzuleitung 20 in den Kathodenraum 14 eintretenden trockenen und heißen Luft teilweise als Dampf bis zur Sättigungsgrenze aufgenommen. Dadurch kommt es in der Brennstoffzelle 10 zu einer Verdampfungserkühlung, die erfindungsgemäß zur Kühlung des in dem Anodenkreislauf zirkulierenden Kühlmittel/Brennstoff-Gemisches genutzt wird. Auf diese Weise kann der sonst üblicherweise in der Anodenableitung 22 vorgesehene Kühler eingespart werden.

In der Brennstoffzelle 10 stellt sich aufgrund des Betriebs mit Wasserdurchbruch und dem Weglassen des sonst in dem Anodenkreislauf vorgesehenen Kühlers ein stationärer Betrieb bei einer Temperatur ein, die zum einen von den Eigenschaften der protonenleitenden Membran 16 abhängt und zum anderen durch die Drehzahl der Pumpe 34 eingestellt werden kann. Vorteilhafterweise beträgt die stationäre Betriebstemperatur zwischen 90 und 110°C, insbesondere 105°C. Dadurch kann die Brennstoffzelle bzw. ein aus mehreren Brennstoffzellen gebildeter Stack nahezu isotherm betrieben werden.

Die Verdampfungskühlung hat, wie vorstehend bereits erwähnt, darüber hinaus den Vorteil, den Massenstrom der trockenen Luft auf das 1,5 bis 2-fache anzuheben. Damit wird die Leistung des Expanders 32 um den gleichen Faktor gesteigert, womit eine Energieeinsparung für die Luftversorgung verbunden ist. Diese Einsparung beträgt ca. 8 kW im Vollastbetrieb. Ein stromab des Expanders 32 angeordneter Luftkühler 46 steht in thermischer Kopplung mit dem nicht näher dargestellten Fahrzeugkühler und hat die Aufgabe, das zum Erreichen einer positiven Wasserbilanz in dem beschriebenen System fehlende Wasser aus dem Abluftstrom auszukondensieren.

Daimler-Benz-Aktiengesellschaft
Stuttgart

EP/VP - MH
13.02.1998

Patentansprüche

1. Brennstoffzellensystem mit mindestens einer Brennstoffzelle (10), die einen Anodenraum (12) und einen Kathodenraum (14) aufweist, die durch eine protonenleitende Membran (16) voneinander getrennt sind, mit einer Kathodenzuleitung (20) zur Zufuhr von sauerstoffhaltigem Gas zum Kathodenraum (14), einer Anodenzuleitung (18) zur Zufuhr eines flüssigen Kühlmittel/Brennstoff-Gemisches zum Anodenraum (12), wobei der Anodenraum (12) in einem einen Gasabscheider und eine Pumpe (34) umfassenden Anodenkreislauf angeordnet ist, dadurch gekennzeichnet, daß eine Kühlung des im Anodenkreislauf zirkulierenden Kühlmittel/Brennstoff-Gemisches durch die Brennstoffzelle (10) erfolgt, die auf einen Betrieb mit Wasserdurchbruch von dem Anodenraum (12) in den Kathodenraum (14) ausgelegt ist.
2. Brennstoffzellensystem nach Anspruch 1, dadurch gekennzeichnet, daß der Anodenkreislauf einen Sammel- und Reinigungsbehälter (50) umfaßt.
3. Brennstoffzellensystem nach Anspruch 2, dadurch gekennzeichnet, daß der Sammel- und Reinigungsbehälter (50) in einem Nebenzweig (48, 66) der Anodenableitung vor dem Gasabscheider (52) angeordnet ist.
4. Brennstoffzellensystem nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß der Kathodenraum (14) in einem eine Kompressor/Expander-Einheit (28, 32) umfassenden Kathodenkreislauf angeordnet ist.

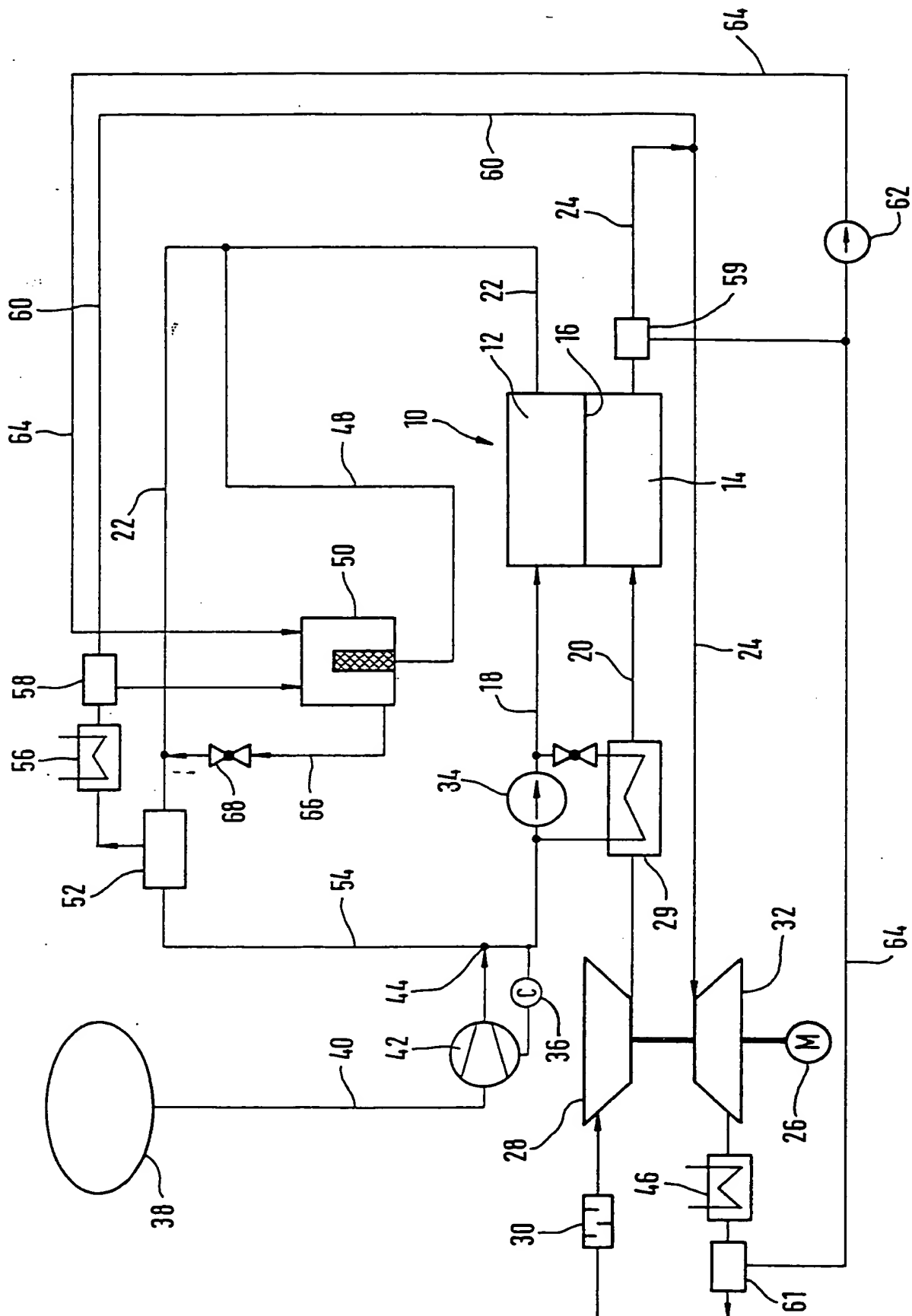
5. Brennstoffzellensystem nach Anspruch 4, dadurch gekennzeichnet, daß in dem Kathodenkreislauf hinter dem Kompressor (28) ein Luftladekühler (29) und hinter dem Expander (32) ein Kühler (46) und mindestens ein Wasserabscheider (61) zur Wasserrückgewinnung vorgesehen ist.

6. Brennstoffzellensystem nach Anspruch 5, dadurch gekennzeichnet, daß eine Rückführung von zurückgewonnenem Wasser in den Anodenkreislauf über eine Rückspeiseleitung (64) vorgesehen ist.

7. Brennstoffzellensystem nach Anspruch 6, dadurch gekennzeichnet, daß die Rückführung von zurückgewonnenem Wasser in den Sammel- und Reinigungsbehälter (50) erfolgt.

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1/1



06-07-1998

TRANSLATION OF APPLICATION

AS FILED (by C. König)

27906

Daimler-Benz-Aktiengesellschaft
Stuttgart

Fuel cell system

The invention relates to a fuel cell system with an anode chamber and a cathode chamber, separated by a proton conducting membrane.

At present, in power generation from liquid energy sources in fuel cell systems with proton exchange membranes (PEM fuel cell), the world-wide focus is on the reforming of methanol in a gas generator system. Hereby a water/methanol mixture is vaporized and in a reformer converted to oxygen, carbon dioxide, and carbon monoxide. Vaporization and reforming are very costly with respect to the energy input. This results in a loss of efficiency for the combined system. In addition, to purify the reformed gas, further processing steps are necessary. The purified gas is then supplied to the PEM fuel cell system. A cooler for cooling the coolant/fuel mixture, circulating in the anode circuit, has to be provided.

Water consumption presents a further problem in the reforming. The product water originating on the cathode side is not sufficient to cover the water budget. This necessitates a separate water tank.

US-PS 5 599 638 presents a fuel cell system, which shows a so-called stack, comprised of several fuel cells, connected to each other. The anode chamber of the stack is part of the anode circuit,

which comprises a heat exchanger for the cooling of the carbon dioxide containing coolant/fuel mixture, which was drained from the anode outlet port, a circulation tank in which the cooled mixture is added to newly taken in coolant/fuel mixture, a gas separator, integrated into the circulation tank, for separating carbon dioxide, and a pump for feeding coolant/fuel mixture from the circulation tank to the anode chamber along a corresponding feed line. The cathode exhaust gas of the fuel cell system, comprising oxygen and water vapor, is carried through a water separator, whereby the separated water is added to the coolant/fuel mixture, which is to be fed to the anode circuit, and part of the remaining oxygen is led into the oxidizing agent feed for the cathode chamber.

Thus the invention has the objective to supply a compact and simple design for a fuel cell system with proton conducting membrane with an improved total efficiency.

To meet this objective this invention proposes a fuel cell system with the features listed in claim 1. According to this invention, during operation of the fuel cell with water breakthrough¹ from the anode chamber into the cathode chamber, an evaporative cooling occurs in the fuel cell when hot air of the cathode chamber absorbs water. According to this invention, this is used for cooling the anode circuit. Due to this feature, a cooler, which otherwise would have to be included in the anode circuit, is no longer necessary.

Further advantageous designs of the invention are described in secondary claims.

The fuel cell is operated in advantageous manner in heat balance equilibrium, e.g. the fuel cell is operated steady-state at a temperature dependent on the properties of the proton conducting membrane,

¹ Unable to find definite translation. Therefore: water- *breach, connection, opening* (The Translator)

and adjustable through the rotational speed of the fluid pump. Depending on the load, the temperature of the steady-state operation is between 90 and 100 °C. Reaching a steady-state operating temperature is of decisive importance for improvements in the efficiency of the fuel cell, or a stack built from several fuel cells, since now an isothermal operation of the stack is possible, i.e. temperature differences across the length of the stack, which are usually on the order of 10°C in conventional systems, no longer occur or no longer occur at a significant level.

In this invention, the evaporative cooling in the fuel cell has the further advantage of increasing the mass flow of dry air to 1.5 to 2 times the normal amount, which leads to an increase in the expander performance by the same factor. This also yields energy savings in the air supply when operating at full load.

Advantageously, after the expander, an air cooler is provided, which is heat coupled to the vehicle's radiator and serves for condensing water, to achieve a positive water balance in the system.

The invention is presented schematically in the figure using a design example, and is described in the following with references to the figure.

The single figure shows in schematic presentation the principle design of the fuel cell in this invention.

The fuel cell system shown in the figure comprises a fuel cell 10, consisting of an anode chamber 12 and a cathode chamber 14, separated by a proton conducting membrane 16. A liquid coolant/fuel mixture is supplied to the anode chamber 12 by an anode feed line 18. All substances which can be oxidized chemically

and have the general structural formula $H-[CH_2O]_n-Y$, with $1 \leq n \leq 5$ and $Y=H$ or $Y=CH_3$, can be used as fuel. The fuel cell system in the illustrated design example is operated with liquid methanol as fuel and water as coolant. Even though only the use of water/methanol mixture will be described in the following, the extent of protection of this application should not be limited to this design example. Especially fluids or ionic or non-ionic water additives with favorable antifreeze properties can be considered as coolants. Possible fuels are e.g. branched variants of the above general formula, such as, for example, di- or trimethoxymethane.

Gas, containing oxygen, is fed into the cathode chamber 14 by a cathode feed line 20. According to the design example, ambient air is used hereby. In the fuel cell 10, the fuel is oxidized at the anode, the oxygen, contained in the air, is reduced at the cathode. Hereby, the proton conducting membrane 16 is coated with suitable catalysts on the corresponding surfaces. Protons can now migrate from the anode side through the proton conducting membrane and combine on the cathode side with oxygen ions to form water. In this electrochemical reaction a voltage is generated between the two electrodes. By connecting many such cells in series or parallel to form a so-called stack, voltages and amperages can be achieved which are sufficient for the propulsion of a vehicle.

At the anode exit, carbon dioxide gas enriched with water and methanol is formed as a product. This fluid/gas mixture is removed from the anode chamber 12 through an anode discharge line 22. The cathode exhaust air, containing residual oxygen and water vapor, is vented through a cathode exhaust gas line 24. To achieve a high efficiency, the ambient air is supplied under excess pressure in the cathode chamber 14. For this purpose, the cathode feed line contains a compressor 28, powered by an electric motor 26,

followed by an *air-loading cooler*² 29, which takes in the desired air mass flow and compresses it to the necessary pressure level. When operating with ambient air, preferably an air filter 30 is included in the inlet area of the cathode feed line 20, upstream of the compressor 28. A portion of the energy needed for the compression of the ambient air can be reclaimed with the help of an expander 32, located in the cathode exhaust line 24. Preferably, the compressor 28, the expander 32, and the electric motor 26 are installed on a common shaft. The fuel cell power is adjusted by controlling the compressor's rotational speed, and thus the available air mass flow.

On the anode side, the water/methanol mixture is circulated at preset pressure by a pump 34, to guarantee a constant over-supply of fuel at the anode. The ratio of water to methanol in the anode feed line is adjusted using a sensor 36, which measures the concentration of methanol in the anode feed line 18. Dependent on this sensor signal, a concentration adjustment for the water/methanol mixture is made, whereby the liquid methanol is taken in from a methanol tank 38 by a methanol feed line 40 and is injected into the anode feed line 18 using an injection nozzle 44, not shown here. An injection pump 42, located in the methanol feed line 40, generates the injection pressure. Thus the anode chamber 12 is constantly supplied with a water/methanol mixture with a constant methanol concentration.

The carbon dioxide, enriched with methanol- and water vapor, now has to be separated from the fluid/gas mixture, which has been removed through the anode discharge line 22. For this purpose, the fluid/gas mixture is fed through the anode discharge line 22 to a gas separator 52, in which the carbon dioxide is separated. The water/methanol mixture remaining in the gas separator 52 is carried back to the anode feed line 18 by a line 54.

² Unable to find a definite translation for this device. *Air-loading cooler* is the literal translation. The device apparently compresses air by cooling it. (The Translator)

The moist carbon dioxide gas, separated in the gas separator 52, is cooled to a temperature as low as possible in a cooler 56. In a following water separator 58 more methanol and water are condensed out. The remaining dry carbon dioxide, with a low content of residual methanol, is fed by a line 60 to the cathode exhaust line 24, where it is mixed with the oxygen rich cathode exhaust air. To separate as much water as possible from the cathode exhaust air, a first water separator 59 is provided after the outlet port of the cathode chamber 14 and a second water separator 61 down stream from the expander 32. The expander 32 serves in the role of a compact condensing turbine, at the exit of which another portion of the water vapor condenses out. The water collected in the water separators 59, 61, is subsequently fed back into a collection- and purification container 50 of a side branch 48, 66 of the anode circuit by a return feed line 64 with integrated return feed pump 62. The collection- and purification container is in particular an ion exchanger.

Within the anode circuit, in the anode discharge line 22, down-stream of the anode outlet port, a branching line 48 is provided, which leads to the collection and purification container. The outlet port of the collection and purification container 50 is connected to the anode discharge line 22 by a line 66 with an integrated valve 68, up-stream of the gas separator 52. The collection- and purification container 50 serves for the collection and purification of the water/methanol mixture arriving from the anode chamber 12, and of the water segregated in the water separator 58, and of the product water, originating at the cathode side, fed back to the anode circuit by the return feed line 64. The valve 68 serves a dual purpose, in preventing back-flow from the anode discharge line 22 into line 66, and in regulating the portion of the mixture from the anode discharge line 22, which is to be conducted through the collection- and purification container.

According to this invention, the fuel cell 10 is operated with water breakthrough³ from the anode chamber 12 into the cathode chamber 14. The liquid water, reaching the cathode chamber 14 in this manner, is partially absorbed, up to the saturation limit, by dry and hot air entering the cathode chamber 14 through the cathode feed line 20. This leads to evaporative cooling in the fuel cell 10, which in this invention is used for cooling the coolant/fuel mixture circulating in the anode circuit. In this manner, a conventional cooler in the anode discharge line 22 is no longer necessary.

Due to the operation with a water breakthrough and the lack of a conventional cooler in the anode circuit, the fuel cell 10 reaches steady-state operation at a temperature, which depends on the properties of the proton conducting membrane 16 and can be regulated by the rotational speed of pump 34. An advantageous steady-state operating temperature is between 90°C and 110°C, in particular 105°C. Thus the fuel cell or a stack of several fuel cells can be operated nearly isothermally.

The evaporative cooling, as mentioned before, has the advantage of increasing the mass flow of dry air to 1.5 to 2 times the normal level. This increases the power of the expander 32 by the same factor, which results in energy savings for the air supply. These savings are approximately 8 kW at full load operation. An air cooler 46, located down-stream of the expander 32, is heat coupled with the vehicle radiator, not shown here, and has the task of condensing enough water out of the exhaust air flow to reach a positive water balance in the described system.

³ See footnote 1. (The Translator)

Patent claims

1. Fuel cell system with at least one fuel cell 10, comprising an anode chamber (12) and a cathode chamber (14), separated by a proton conducting membrane (16), with a cathode feed line (20) for the supply of gas containing oxygen to the cathode chamber (14), an anode feed line (18), for supply of liquid coolant/fuel mixture to the anode chamber (12), whereby the anode chamber is contained in an anode circuit, comprising a gas separator and a pump (34), characterized by the coolant/fuel mixture, circulating in the anode circuit, being cooled by the fuel cell (10), which is designed for operation with water breakthrough⁴ from the anode chamber (12) to the cathode chamber (14).
2. Fuel cell system, according to claim 1, characterized by the anode circuit comprising a collection- and purification container (50).
3. Fuel cell system, according to claim 2, characterized by the collection and purification container being located in a side branch (48, 66) of the anode discharge line, before the gas separator (52).
4. Fuel cell system, according to one of the claims 1 to 3, characterized by the cathode chamber (14) being located in a cathode circuit, comprising a compressor/expander unit (28, 32).

⁴ See footnote 1. (The translator)

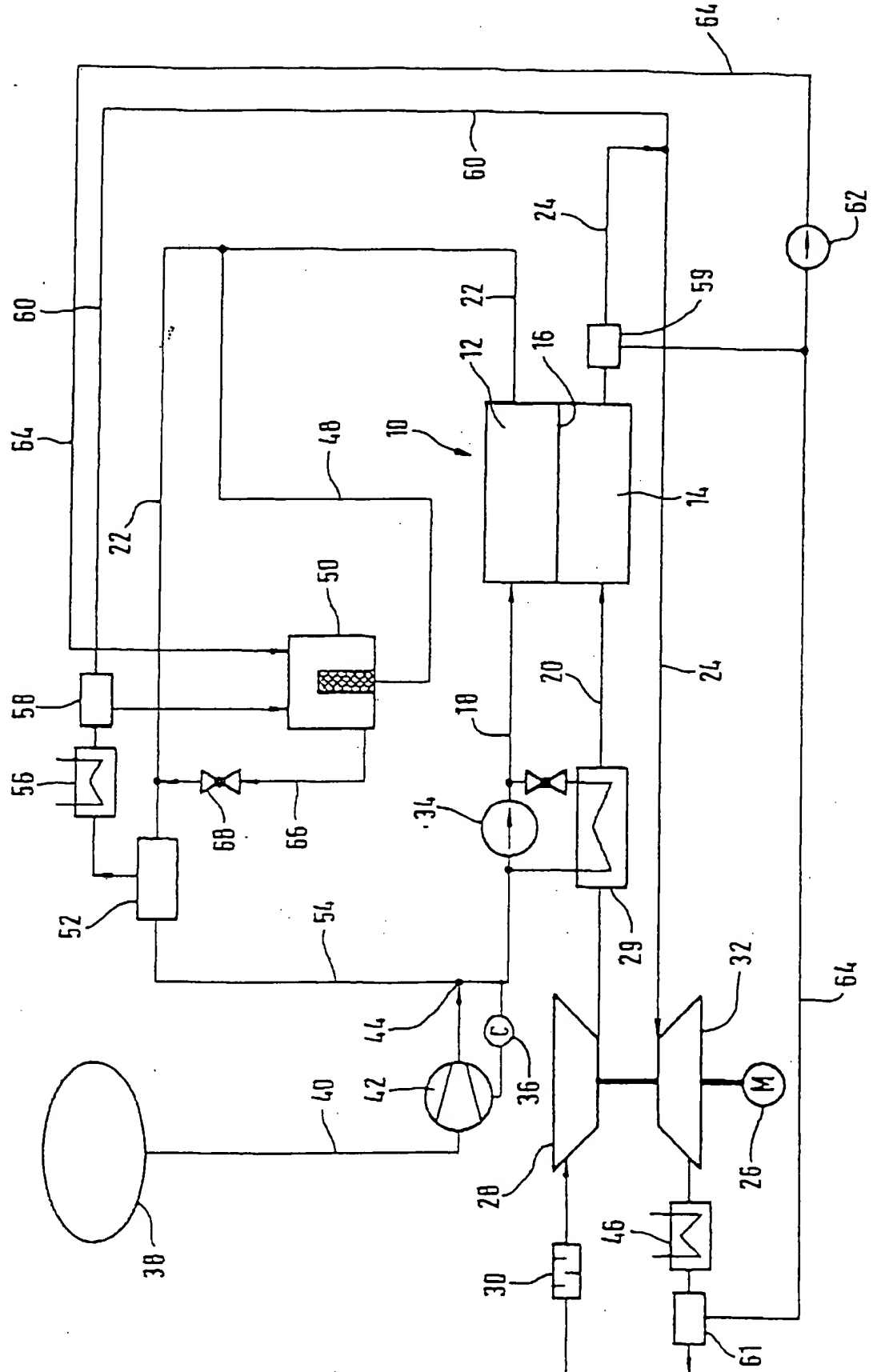
5. Fuel cell system, according to claim 4, characterized by an *air-loading cooler*⁵ being provided after the compressor (28) in the cathode circuit, and one cooler and at least one water separator (61) for water recovery being provided after the expander.
6. Fuel cell system, according to claim 5, characterized by the re-circulation of recovered water into the anode circuit by a return feed line (64).
7. Fuel cell system, according to claim 6, characterized by the re-circulation of recovered water into the collection- and purification container (50).

⁵ See footnote 2. (The Translator)

Summary

Fuel cell system with at least one fuel cell, comprising an anode chamber and a cathode chamber, separated by a proton conducting membrane, with a cathode feed line for the supply of gas containing oxygen to the cathode chamber, an anode feed line for the supply of liquid coolant/fuel mixture to the anode chamber, whereby the anode chamber is contained in an anode circuit comprising a gas separator and a pump. The coolant/fuel mixture, circulating in the anode circuit, is cooled by the fuel cell, which is operating with water breakthrough⁶ from the anode chamber into the cathode chamber. Because of the evaporative cooling in the fuel cell, achieved in this manner, the coolant/fuel mixture is cooled at a steady-state operating temperature being reached dependent on the membrane properties and the rotational speed of the pump. Thus, no separate cooler is necessary in the anode circuit.

⁶ See footnote 1. (The Translator)



filing but does not maintain shareholder status throughout the course of the litigation, the plaintiff no longer has standing to bring the action. See *Schilling v. Belcher*, 582 F.2d 995, 996 (5th Cir.1978) (holding that shareholder whose shares were sold during pendency of derivative suit no longer had standing to continue bringing the action); see also *Lewis v. Chiles*, 719 F.2d 1044, 1047 (9th Cir.1983) (same).

[2] Here, Johnson was a shareholder when he filed in the Court of Federal Claims in the spring of 2000. However, Johnson's shares were canceled under the plan of reorganization in bankruptcy, approved on September 15, 2000. Johnson therefore did not maintain his shareholder status throughout the litigation and as such his standing to bring the takings claim terminated.

Because we decide this case on the ground that Johnson lost standing to bring the takings claim because he was not a shareholder throughout the litigation, we need not reach the issue considered by the Court of Federal Claims and raised here on appeal of whether the bankruptcy trustee abandoned the takings claim such that Johnson was free to bring it on behalf of JPI. Nor need we address the Court of Federal Claims' analysis regarding whether Johnson, on the merits, presented a valid takings claim. We accordingly affirm the grant of summary judgment in favor of the government by the Court of Federal Claims.

AFFIRMED.



Arjun SINGH, Appellant,

v.

Anthony J. BRAKE, Appellee.

No. 01-1621.

**United States Court of Appeals,
Federal Circuit.**

**Nonprecedential Opinion Issued
Oct. 16, 2002.***

Jan. 29, 2003.

Interference proceeding was brought involving invention of DNA construct. On remand, 222 F.3d 1362, the Board of Patent Appeals and Interferences awarded judgment in interference to patentee, and applicant appealed. The Court of Appeals, Lourie, Circuit Judge, held that: (1) applicant failed to establish that he had conceived of plan to design DNA construct before patentee's priority date, and (2) patentee's patent application which he based his priority claim, provided adequate written description of invention and was enabling.

Affirmed.

1. Patents ⇨106(1)

Refusal of Board of Patent Appeals and Interferences to consider issues raised for first time on remand of interference proceeding was not abuse of discretion; arguments not raised at outset of interference could properly be seen as waived. 37 C.F.R. § 1.655(b).

2. Patents ⇨90(1)

"Conception," for purpose of determining priority, must encompass all limitations of claimed invention, and is complete only when idea is so clearly defined in

* Originally published at 48 Fed.Appx. 766.

inventor's mind that only ordinary skill would be necessary to reduce invention to practice, without extensive research or experimentation. 35 U.S.C.A. § 102(g).

See publication Words and Phrases for other judicial constructions and definitions.

3. Patents ⇨90(1)

Priority of invention and its constituent issues of conception and reduction to practice are questions of law predicated on subsidiary factual findings.

4. Patents ⇨91(1)

Junior party whose effective filing date is earlier than date senior party's patent issued and who is seeking determination of priority must demonstrate by preponderance of evidence either reduction to practice before senior party's priority date, or prior conception coupled with reasonable diligence in reducing invention to practice from time just prior to senior party's entry into field to junior party's own reduction to practice. 35 U.S.C.A. § 102(g).

5. Patents ⇨91(3)

Party claiming priority of inventorship, who seeks to prove conception via oral testimony of putative inventor, must proffer evidence corroborating that testimony. 35 U.S.C.A. § 102(g).

6. Patents ⇨91(3)

There is no particular formula that alleged inventor must follow in providing corroboration of his testimony of conception, for purpose of establishing priority of inventorship; rather, whether inventor's testimony has been sufficiently corroborated is determined by "rule of reason" analysis, in which evaluation of all pertinent evidence must be made so that sound determination of credibility of inventor's story may be reached. 35 U.S.C.A. § 102(g).

7. Patents ⇨91(4)

Junior party seeking determination of priority of inventorship failed to establish

that he had conceived of plan to design DNA construct before senior party's priority date, despite notebook entries articulating problem to be solved and his ordering of material potentially needed to solve problem; entries did not provide solution to problem, and order was canceled on same day, with notation that problem would be solved in different manner. 35 U.S.C.A. § 102(g).

8. Patents ⇨91(4)

Junior party seeking determination of priority of inventorship for DNA construct failed to establish that he exercised reasonable diligence toward reduction to practice before senior party's priority date; junior party's evidence of diligence primarily consisted of various pages from his laboratory notebook that were unexplained as to content and relevance to invention, and uncorroborated. 35 U.S.C.A. § 102(g).

9. Patents ⇨314(5), 324.55(3.1)

Whether specification supports patent claim, and thus satisfies written description requirement, is question of fact which is reviewed under substantial evidence standard. 35 U.S.C.A. § 112.

10. Patents ⇨99

Inventor provided adequate written description of invention for DNA construct in his patent application, and thus was entitled to benefit of application date, for purpose of establishing priority of inventorship. 35 U.S.C.A. §§ 102(g), 112, ¶ 1.

11. Patents ⇨314(5)

Patent enablement is question of law based on underlying factual determinations. 35 U.S.C.A. § 112.

12. Patents ⇨99

Patent application for DNA construct was enabling, and thus inventor was entitled to benefit of application date, for pur-

pose of establishing priority of inventorship. 35 U.S.C.A. §§ 102(g), 112.

Sharon E. Crane, Burns, Doane, Swecker & Mathis, LLP, of Alexandria, VA, argued for appellant. With her on the brief were R. Danny Huntington, Bruce T. Wieder, and Donna M. Meuth.

Debra A. Shetka, Morrison & Foerster LLP, of Palo Alto, CA, argued for appellee. With her on the brief was Thomas E. Ciotti. Of counsel on the brief were Rachel Krevans and Jill Neiman, Morrison & Foerster LLP, of San Francisco, CA. Also of counsel on the brief were Robert P. Blackburn and Joseph H. Guth, Chiron Corporation, of Emeryville, CA.

Before LOURIE, Circuit Judge,
FRIEDMAN, Senior Circuit Judge, and
PROST, Circuit Judge.

LOURIE, Circuit Judge.

Arjun Singh appeals from the remand decision of the United States Patent and Trademark Office Board of Patent Appeals and Interferences awarding judgment in an interference to Anthony Brake. *Brake v. Singh*, Inter. No. 102,728, Paper No. 199 (Bd. Pat.App. & Inter. June 19, 2001). Because the Board's decision was supported by substantial evidence and was not contrary to law, we affirm.

BACKGROUND

This case arises out of an interference declared on November 12, 1991, involving a count corresponding to all thirty-seven claims of Brake's U.S. Patent 4,870,008 (hereinafter "the Brake patent") and claims 8 and 19-21 of Singh's U.S. Application 07/552,719.

The Brake patent issued from U.S. Application 07/081,302, filed August 3, 1987, which was a continuation of, and was ac-

corded the benefit of, U.S. Application 06/522,909 (hereinafter "Brake 2"), filed August 12, 1983, assigned to Chiron Corporation. Singh's Application 07/552,719 was filed July 16, 1990, and was accorded the benefit of U.S. Application 06/506,098 (hereinafter "the Singh application"), filed June 20, 1983, and U.S. Application 06/488,323, filed April 25, 1983, both assigned to Genentech, Inc.

Because the earlier Singh application predated Brake 2, Singh was initially designated the senior party in the interference. However, Brake 2 was a continuation-in-part of U.S. Application 06/457,325 (hereinafter "Brake 1"), filed January 12, 1983, and Brake successfully moved for the benefit of the filing date of Brake 1 with respect to the count in the interference. Brake also successfully moved to attack the benefit accorded Singh of the April 25, 1983 filing date of U.S. Application 06/488,323. Brake was then designated as the senior party.

The count, which is identical to claim 1 of Brake 2, reads as follows:

1. A DNA construct comprising a sequence of the following formula:

5'-L-S-Gene*-3',

where:

L encodes a *Saccharomyces* alpha-factor leader sequence recognized by a yeast host for secretion;

S encodes a spacer sequence providing processing signals resulting in the enzymatic processing by said yeast host of a precursor polypeptide encoded by L-S-Gene* into the polypeptide encoded by Gene*, S containing the sequence 5'-R₁-R₂-3' immediately adjacent to the sequence Gene*, R₁ being a codon for lysine or arginine, R₂ being codon for arginine, with the proviso that S not contain the sequence 5'-R₃-R₄-X-3', where R₃=R₁, R₄=R₂.

and X encodes a processing signal for dipeptidylaminopeptidase A; and Gene* encodes a polypeptide foreign to *Saccharomyces*.

Brake, Paper No. 199 at 6.

The DNA construct of the count thus includes three basic components: (1) a segment, "L," which encodes an alpha-factor leader sequence;¹ (2) a segment, "S," which includes a first codon,² R₁, encoding either lysine or arginine, followed by a second codon, R₂, encoding arginine; and (3) a gene, "Gene*," which encodes a protein of interest, in particular, a polypeptide foreign to (*i.e.*, not naturally produced by) the yeast *Saccharomyces*. See *Brake* patent, col. 2, ll. 11-16, 38-43.

After the DNA construct has been introduced into the yeast cell, *e.g.*, via a plasmid vector, the cell "expresses" the construct, producing a polypeptide having the sequence of amino acids encoded by the DNA. The sequence of the resulting polypeptide, like the DNA encoding it, is divided into three regions: the alpha-factor leader, the spacer sequence including either a lysine-arginine or an arginine-arginine two-amino acid block, and the amino acid sequence of the protein of interest ("gene product").

According to the record in this case, the leader sequence functions to target the polypeptide for secretion from the yeast cell. During secretion, the yeast enzyme KEX-2 recognizes the lysine-arginine or arginine-arginine spacer sequence in the polypeptide and cleaves the polypeptide at the junction between the spacer and the

gene product. As a result, the desired gene product is released into the extracellular medium, free of the leader and spacer portions of the polypeptide. See *Brake*, Paper No. 164 at 2. Because the yeast cell exports rather than retains the desired protein, protein purification is considerably simplified. See *id.*

The following is a statement of the facts as set forth in our earlier opinion in this case. *Singh v. Brake*, 222 F.3d 1362, 55 USPQ2d 1673 (Fed.Cir.2000). As we noted in that opinion, the factual context of Singh's alleged conception of the claimed DNA construct is based on his statements to the PTO and other record evidence. Absent qualification, the facts set forth here are not disputed by the parties.

In the course of Singh's attempts to design the claimed DNA construct in August 1982, he prepared plasmid p57, a circular DNA molecule containing the alpha-factor leader sequence and a spacer sequence directly adjacent to it. See *Singh* Decl. ¶21. During that same month, Singh incorporated the gene for human protein interferon D ("IFN-D") into p57, thereby yielding plasmid p58. See *id.* In p58, the gene was also positioned adjacent to the spacer sequence, such that the leader, spacer, and gene sequences were all oriented in a fashion identical to the claimed construct. From September 6 to 11, 1982, Singh's assistant, Dr. June Lugovoy, isolated the DNA segment from p58 containing the alpha-factor leader, spacer, and IFN-D sequence, and inserted that segment

1. Alpha-factor, also known as alpha-mating factor, is a peptide released by the budding yeast *Saccharomyces cerevisiae* when a haploid cell is prepared to mate. See Bruce Alberts et al., *Molecular Biology of the Cell* 722 (3d ed.1994). The yeast cell exports alpha-factor by way of a "leader sequence," which is attached to alpha-factor and signals that the peptide is to be exported from the

cell. See U.S. Application 06/506,098 at 3, II. 3-5. That sequence is typically removed from alpha-factor upon secretion. See *id.* at 3, II. 1-3. It is the alpha-factor leader sequence alone that is incorporated into the claimed construct.

2. A "codon" is a set of three nucleotides that codes for a particular amino acid.

(hereinafter "the p60 DNA construct") into yeast plasmid YEp9PT ("p60"). See *id.* ¶ 26. Plasmid p60 was then introduced into yeast cells to determine whether the p60 DNA construct would generate IFN-D. See *id.* ¶ 27.

On October 1, 1982, protein sequencing chemist Bill Kohr informed Singh that the IFN-D expressed by yeast cells transformed with p60 contained eight additional amino acids not normally present in natural IFN-D. See *id.* ¶ 33. On approximately that same date, Singh alleges that he conceived the claimed DNA construct, *i.e.*, he devised a plan to redesign the p60 DNA construct in order to obtain the desired gene product, IFN-D, free of those additional amino acids. See *id.* ¶ 34. Specifically, Singh claims that he realized that he would need to remove eight unwanted codons (twenty-four nucleotides) from the p60 DNA construct, and that he planned to accomplish this deletion by use of a technique known as "loop deletion mutagenesis."

On November 24, 1982, Singh wrote a laboratory notebook entry setting forth the undesired eight codons in the p60 DNA construct, as well as the twelve nucleotides on either side of that eight codon segment (the "flanking sequences"). See Singh Decl. ¶ 45. On that date, Singh also ordered a linear, 24-nucleotide sequence (a "24-mer") that comprised the nucleotides of the flanking sequences.³ This order was canceled on the same day, and a notation in Singh's laboratory notebook stated that Singh would perform the deletion experiment in a different way "without

changing codons." *Id.* On December 1, 1982, Singh ordered another 24-mer for the deletion experiment. This 24-mer was precisely complementary to the flanking sequences set forth in the November 24 entry. See Singh Decl. ¶ 47. DNA chemist Peter Ng testified that he synthesized the 24-mer for Singh on December 20, 1982. See Ng Decl. ¶ 11; Ng Dep. at 36. Singh affixed the order into his notebook on December 21, 1982, with a notation "oligonucleotide for making in-frame deletion of alpha pro-IFN-D junction."⁴ Singh alleges that these facts corroborate his testimony that he conceived the claimed DNA construct before January 12, 1983, the filing date of Brake 1.

Id. at 1364-65, 222 F.3d 1362, 55 USPQ2d at 1674-75 (footnote omitted).

At the final hearing on May 11, 1998, Singh sought: (1) to contest the interlocutory order granting Brake the benefit of Brake 1; (2) to prove Singh's conception of the invention of the count prior to Brake 1's January 12, 1983 filing date; and (3) to show diligence throughout the "critical period" from just prior to January 12, 1983, until actual reduction to practice. Singh was unsuccessful with respect to all three issues, and final judgment was issued in favor of Brake on August 31, 1998. *Brake*, Paper No. 164.

Singh appealed to this court, contesting Brake's entitlement to the benefit of Brake 1 and contesting the Board's finding that Singh had failed to prove conception prior to the Brake 1 filing date. We held that certain of the Board's key findings underlying its conclusion that Singh had failed to

3. Actually, this statement is incorrect. The 24-mer sequence that Singh ordered on November 24, 1982, was not identical to the nucleotides of the flanking sequences, but instead included several "preferred codons."

4. This point is disputed. Singh has provided no corroboration of his assertion that this notation was actually made on December 21, 1982. Like the other pages of Singh's notebook, this page was not witnessed until 1986, and, even then, there is no proof that the notation existed at the time of the witnessing.

prove conception of the subject matter of the interference prior to the effective filing date of Brake were unsupported by substantial evidence, and we vacated and remanded. *Singh*, 222 F.3d at 1370, 55 USPQ2d at 1679. We also found that the Board did not address whether Brake 1 adequately described and enabled the disputed subject matter of the count under 35 U.S.C. § 112, ¶ 1, and we remanded for determination of those issues as well. *Id.* at 1371, 222 F.3d 1362, 55 USPQ2d at 1679.

On remand, the Board permitted the parties to submit briefs on the remanded issues, but returned Singh's enablement and written description briefs (as well as Brake's corresponding reply briefs) with its opinion, stating that Singh had failed to comply with the requirements of 37 C.F.R. § 1.655(a) and (b) by presenting new arguments not raised in the original opposition.

In an eighty-nine-page opinion with an additional seventeen-page concurrence, *Brake*, Paper No. 199, the Board addressed each of the issues on remand and concluded: (1) that Brake 1 adequately described and enabled the invention of the count, and Brake was therefore entitled to the benefit of Brake 1's filing date; (2) that Singh had not met his burden of proving conception prior to the filing date of Brake 1; and (3) that even if it were assumed, *arguendo*, that Singh had conceived the invention prior to Brake's filing date, Singh had not met his burden of demonstrating diligence between conception and reduction to practice.

Singh now appeals again. We have jurisdiction pursuant to 35 U.S.C. § 141 and 28 U.S.C. § 1295(a)(4)(A) (2000).

DISCUSSION

A. Return of Briefs

[1] Pursuant to our earlier decision's remand "for determination of those issues that were properly raised during the earli-

er proceedings," *Singh*, 222 F.3d at 1371, 55 USPQ2d at 1679, the Board invited the parties to submit briefs on the issues of Singh's case for priority and Brake's sustenance of his burden of proof with respect to written description and enablement. *Brake*, Paper No. 199 at 12. After the parties submitted the invited briefs, the Board determined that Singh had presented new arguments in derogation of the Board's reminder that only issues that were properly raised in the original opposition were entitled to review at the final hearing. *Id.* at 13. In response, the Board returned all of the newly submitted briefs to the parties without further consideration, holding that the briefs contained, "almost exclusively, new arguments, and lack the showing that Preliminary Motion 2 [concerning the Brake patent's entitlement to the Brake 1 filing date] should be modified." *Id.* at 15.

Singh argues that the Board erred in refusing to consider briefs submitted by Singh on remand. We review the Board's application of its rules for an abuse of discretion. *Brown v. Barbacid*, 276 F.3d 1327, 1332, 61 USPQ2d 1236, 1238 (Fed. Cir.2002). Although returning the briefs to the parties is a rather extraordinary measure, we do not find any abuse of discretion in the Board's doing so. 37 C.F.R. § 1.655(b) states:

A party shall not be entitled to raise for consideration at final hearing any matter which properly could have been raised by a motion under § 1.633 or 1.634 unless the matter was properly raised in a motion that was timely filed by the party under § 1.633 or 1.634 and the motion was denied or deferred to final hearing, the matter was properly raised by the party in a timely filed opposition to a motion under § 1.633 or 1.634 and the motion was granted over the opposition or deferred to final hearing, or the party shows good cause why

the issue was not properly raised by a timely filed motion or oppositions.

37 C.F.R. § 1.655(b) (2002).

Because the Board found that Singh was attempting to raise in his briefs matters that could have been but were not raised at the outset of the interference, *see Brake*, Paper No. 199 at 12, the Board was acting properly within its discretion when it refused to consider the briefs. Singh could have raised his written description and enablement arguments at the outset of the interference; to the extent that he did not do so, those arguments have been waived. As we stated in *Credle v. Bond*, 25 F.3d 1566, 30 USPQ2d 1911 (Fed.Cir. 1994), the Board does not abuse its discretion when it declines to consider untimely arguments. *Id.* at 1572 n. 14, 25 F.3d 1566, 30 USPQ2d at 1916 n. 14. Furthermore, because the Board explicitly stated in its November 2, 2000 order that additional briefing was optional, *Brake*, Paper No. 179 at 5, it is difficult to see how the subsequent refusal to consider the briefs could have been an abuse of discretion.

Singh also asserts that the Board refused to consider certain arguments made in his "original" Main Brief. We find no abuse of discretion. Again, Singh did not show good cause for failing to raise these arguments at the preliminary motion stage, and the Board was entitled to decline to consider them.

B. Conception and Reduction to Practice

[2] "Conception is the formation 'in the mind of the inventor of a definite and permanent idea of the complete and operative invention, as it is therefore to be applied in practice.'" *Kridl v. McCormick*, 105 F.3d 1446, 1449, 41 USPQ2d 1686, 1689 (Fed.Cir.1997) (citations omitted). A conception must encompass all limitations of the claimed invention, *see id.*, and "is complete only when the idea is so clearly defined in the inventor's mind that only

ordinary skill would be necessary to reduce the invention to practice, without extensive research or experimentation," *Burroughs Wellcome Co. v. Barr Labs. Inc.*, 40 F.3d 1223, 1228, 32 USPQ2d 1915, 1919 (Fed.Cir.1994).

[3] Priority of invention and its constituent issues of conception and reduction to practice are questions of law predicated on subsidiary factual findings. *Brown*, 276 F.3d at 1332, 61 USPQ2d at 1238; *Hitzeman v. Rutter*, 243 F.3d 1345, 1353, 58 USPQ2d 1161, 1166 (Fed.Cir.2001). Accordingly, we review *de novo* the Board's legal conclusions with respect to priority, conception, and reduction to practice, 5 U.S.C. § 706 (2000); *Brown*, 276 F.3d at 1332, 61 USPQ2d at 1238; *Hitzeman*, 243 F.3d at 1353-54, 58 USPQ2d at 1166-67, and we review factual findings by the Board for substantial evidence, *Dickinson v. Zurko*, 527 U.S. 150, 119 S.Ct. 1816, 144 L.Ed.2d 143 (1999); *In re Gartside*, 203 F.3d 1305, 1315, 53 USPQ2d 1769, 1775 (Fed.Cir.2000).

[4] A junior party whose effective filing date is earlier than the date the senior party's patent issued and who is seeking a determination of priority must demonstrate by a preponderance of the evidence either reduction to practice before the senior party's priority date, or prior conception coupled with reasonable diligence in reducing the invention to practice from a time just prior to the senior party's entry into the field to the junior party's own reduction to practice. 35 U.S.C. § 102(g) (2000); *Griffin v. Bertina*, 285 F.3d 1029, 1032, 62 USPQ2d 1431, 1433 (Fed.Cir. 2002); *Mahurkar v. C.R. Bard, Inc.*, 79 F.3d 1572, 1577, 38 USPQ2d 1288, 1290 (Fed.Cir.1996).

[5, 6] It is well established that when a party seeks to prove conception via the oral testimony of a putative inventor, the

party must proffer evidence corroborating that testimony. See *Mahurkar*, 79 F.3d at 1577, 38 USPQ2d at 1290; *Price v. Symsek*, 988 F.2d 1187, 1194, 26 USPQ2d 1031, 1036 (Fed.Cir.1993). That rule addresses the concern that a party claiming inventorship might be tempted to describe his actions in an unjustifiably self-serving manner in order to obtain a patent or to maintain an existing patent. See *Eibel Process Co. v. Minn. & Ont. Paper Co.*, 261 U.S. 45, 60, 43 S.Ct. 322, 67 L.Ed. 523 (1923); *Kridl*, 105 F.3d at 1450, 41 USPQ2d at 1689 ("The tribunal must also bear in mind the purpose of corroboration, which is to prevent fraud, by providing independent confirmation of the inventor's testimony."); *Price*, 988 F.2d at 1194-95, 26 USPQ2d at 1036-37. There is no particular formula that an inventor must follow in providing corroboration of his testimony of conception. See *Kridl*, 105 F.3d at 1450, 41 USPQ2d at 1689. Rather, whether a putative inventor's testimony has been sufficiently corroborated is determined by a "rule of reason" analysis, in which "an evaluation of all pertinent evidence must be made so that a sound determination of the credibility of the inventor's story may be reached." *Price*, 988 F.2d at 1195, 26 USPQ2d 1031 at 1037. However, that "rule of reason" analysis does not alter the requirement of corroboration of an inventor's testimony. *Brown*, 276 F.3d at 1335. Evidence of the inventive facts must not rest alone on the testimony of the inventor himself. *Cooper v. Goldfarb*, 154 F.3d 1321, 1330, 47 USPQ2d 1896, 1903 (Fed.Cir.1998).

[7] Singh argues that the Board did not consider the totality of the corroborative evidence establishing Singh's conception, but only considered individual pieces of evidence in "total isolation from one another." Specifically, Singh argues that his November 24, 1982 notebook entry and his ordering of the specific 24-mer oligonucleotide ultimately used to carry out the

loop deletion mutagenesis method (in February 1983) establish that he had a definite and permanent idea of the structure of a DNA construct within the count and of an operative way of making it prior to Brake 1's filing date.

We disagree. First, as we stated in our earlier opinion, *Singh*, 222 F.3d at 1368, 55 USPQ2d at 1677, the Board correctly held as a matter of law that Singh failed to prove that he conceived the claimed construct prior to December 1, 1982. In his November 24, 1982 notebook entry, Singh identified the twenty-four nucleotides encoding the eight extraneous amino acids present in the IFN-D generated by the p60 DNA construct, labeling them with the notation, "sequence to be removed." He also identified in that entry the twelve nucleotides immediately upstream and the twelve nucleotides immediately downstream from those twenty-four, i.e., the flanking segments. Accordingly, he may have articulated in that entry the problem to be solved, namely, the need to eliminate the twenty-four nucleotides encoding the extraneous amino acids. Nonetheless, substantial evidence supports the Board's finding that that entry alone was insufficient to corroborate Singh's testimony. Even if the entry expressed the problem, it did not provide the solution. See *Brake*, Paper No. 164 at 22-24. The Board's key findings in this regard, both of which are supported by substantial evidence in the notebook entry itself, are: (1) that a linear 24-mer other than the one necessary to accomplish the deletion was first ordered, and (2) that the order was canceled the same day, with a notation "will do in a different way and w/o changing codons." *Id.* at 23-24.

Secondly, as noted above, the 24-mer sequence that Singh initially ordered on November 24, 1982, was not identical to the nucleotides of the flanking sequences.

Instead, he included several "preferred codons," casting doubt on the accuracy of Singh's statement that he ordered that 24-mer "[i]n order to remove this sequence by oligonucleotide deletion mutagenesis." While it remains unclear exactly what Singh "planned" to do on November 24, 1982, his identification of preferred codons suggests to us that his plans may not have included the use of loop deletion mutagenesis.

The Board duly considered the fact that the 24-mer ordered by Singh on December 1, 1982, was indeed complementary to the four codons on each side of the sequence Singh allegedly desired to delete. See, e.g., *Brake*, Paper No. 199 at 13-14, 19, 58-59, 77-78. The Board also reviewed Singh's notebook pages purporting to demonstrate conception. The Board concluded, and we agree, that "Singh's entire case for conception rests on the order of a 24-mer and an uncorroborated notation in a corner of Dr. Singh's notebook." *Id.* at 84.

There is nothing in Singh's notebook that corroborates his testimony that the November 24, December 1, and December 21 entries were meant to be read together. Even viewing all of these entries together, however, we find that the sum falls short of proving by a preponderance of the evidence that Singh had a definite and permanent idea of an operative method of making the DNA construct of the count prior to Brake 1's filing date. As the Board observed, the notebook entries do not provide any protocol or outline of the loop deletion mutagenesis procedure: "At best, the notation states a goal which Dr. Singh hopes to achieve; i.e., an in-frame deletion of the α pro-IFN-D junction." *Id.* at 61. Adelman et al., *In Vitro Deletional Mutagenesis for Bacterial Production of the 20,000-Dalton Form of Human Pituitary Growth Hormone*, 2 DNA 183 (1983), which described the loop deletion mutagenesis procedure, also described using oli-

gonucleotides complementary to nucleotide sequences flanking codons to be deleted as probes for identifying plasmids from which the codons had been deleted. *Id.* at 188. We find it no less plausible that Singh was ordering the 24-mer for use as a probe than it was that he was ordering it for use in the loop deletion mutagenesis procedure. Indeed, Singh has pointed to no evidence in the record in support of his assertion that loop deletion mutagenesis was developed at Genentech in late 1982 (the Adelman et al. paper was published in 1983), let alone that Dr. Singh knew of any such developments prior to Brake 1's filing date. The burden was on Singh to prove that he as the inventor had a definite and permanent idea of how to make the construct. See *Coleman v. Dines*, 754 F.2d 353, 360, 224 USPQ 857, 863 (Fed.Cir. 1985). That he did not do.

Finally, we address Singh's argument set forth in his brief that, "[w]ith respect to the issue of conception, this Court previously made specific findings . . . that Singh articulated a specific plan to design the claimed construct by the loop deletion method on November 24, 1982." That statement is a mischaracterization of our earlier opinion, in which we simply said that the Board needed to consider the totality of the evidence, including evidence of Singh's identification of the "sequence to be removed" and the twelve nucleotides immediately upstream and downstream from this sequence, as well as of his ordering of a 24-mer identical to the sequences flanking the undesired sequence. We are satisfied that the Board has done so.

Thus, after review of the record evidence in light of the proper legal standards, we conclude that substantial evidence supports the Board's key finding that no evidence links the nucleotide Singh ordered on December 1, 1982, with a plan

to design the claimed construct prior to January 12, 1983.

[8] Because we find that Singh did not meet his burden of demonstrating conception prior to Brake 1's filing date by a preponderance of the evidence, we need not address Singh's arguments regarding reduction to practice. However, we note the Board's finding that, apart from attorney argument, "Singh's evidence of diligence primarily consists of various pages from Dr. Singh's laboratory notebook which are (i) unexplained as to content and relevance to the invention of the Count, and (ii) uncorroborated." *Brake*, Paper No. 199 at 88. We agree that Singh's activities completed on December 20, 1982, were the only relevant, corroborated activities performed by Singh prior to Brake 1's January 12, 1983, filing date, and, as a result, Singh failed to prove reasonable diligence toward reduction to practice by a preponderance of the evidence.

C. Written Description and Enablement

[9,10] Whether a specification supports a claim corresponding to a count, and thus satisfies the written description requirement of 35 U.S.C. § 112, ¶ 1, is a question of fact, *Vas-Cath v. Mahurkar*, 935 F.2d 1555, 1562, 19 USPQ2d 1111, 1116 (Fed.Cir.1991), and is, in appeals from the United States Patent and Trademark Office, reviewed under the substantial evidence standard. *In re Gartside*, 203 F.3d at 1315, 53 USPQ2d at 1775.

5. Singh bases that number on the formula " $((R)_r-(GAXYCX)_n-\text{Gene})_y$ " disclosed at page 3, line 33, of Brake 1, in which R = CGX or AZZ; r = "an integer of from 2 to 4, ..., preferably 2"; X = T, G, C, or A; Y = G or C; y = "an integer of least one and usually not more than 10, more usually not more than four ..."; Z = A or G; and n = "0 or an integer which will generally vary from 1 to 4, usually 2 to 3."

Singh argues that the Board erred in concluding that Brake is entitled to the benefit of the Brake 1 application. First, Singh contends that Brake did not provide an adequate written description of the invention of the count in the Brake 1 application, and should not be entitled to its benefit. According to Singh, Brake 1 disclosed a large genus, allegedly encompassing over 9000 species⁵ (n is 0 or 1 to 4), of which the count is directed to only two (i.e., those where n = 0). Secondly, Singh asserts that Brake 1 does not provide an enabling disclosure with respect to the invention of the count, arguing that Brake 1 does not disclose how to make and use the "n = 0" embodiment, and that "the techniques which were available to Brake at the time of filing the Brake 1 Application were not sufficient to obtain the DNA constructs of the Count." Singh also argues that Brake 1 "is replete with passages which guide one of ordinary skill in the art to constructs wherein n > 0, which constructs are not encompassed by the Count." Finally, Singh argues that "during prosecution of the Brake 2 Application, Brake argued that the results obtained with the n = 0 construct were unexpected, because those of ordinary skill in the art believed that the Glu-Ala sequences were required."

Singh's arguments are not persuasive. First, we disagree with Singh's argument that the invention of the count represents just two of 9000+ species disclosed in Brake 1. Singh's calculation of 341 permu-

According to Singh, Each "R" can encode either Lys or Arg, so (R)_r can encode twenty-eight (i.e., $2^2 + 2^3 + 2^4$) different amino acid sequences. In addition, each "GAXYCX" sequence can encode any of four amino acid sequences: Asp-Pro, Asp-Ala, Glu-Pro, or Glu-Ala, so (GAXYCX)_n can encode 341 (i.e., $4^0 + 4^1 + 4^2 + 4^3 + 4^4$) different amino acid sequences. Thus, Singh argues that the Brake 1 formula covers 9548 (i.e., 28×341) different species.

tations for $(\text{GAXYCX})_n$ is apparently based on an unwarranted assumption that each iteration of the parenthetical sequence is independently chosen. However, as Brake pointed out, because the variable 'n' is outside the parentheses, $(\text{GAXYCX})_n$ can code for either no amino acids (i.e., when $n = 0$), or 1 to 4 copies of one of four different amino acid sequences (i.e., Asp-Pro, Asp-Ala, Glu-Pro, or Glu-Ala). *Brake*, Paper No. 199 at 20-21 n. 13. Thus, there are at most only seventeen (i.e., $4^0 + 4^1 + 4^1 + 4^1 + 4^1$) permutations of that sequence. Even among those seventeen, however, we agree with Brake that there are only two meaningful embodiments: one in which a dipeptidylaminopeptidase A (DPAP) signal is present (i.e., $n = 1$ to 4), and one in which it is not (i.e., $n = 0$).

Moreover, Singh's calculation of twenty-eight possibilities for the Lys/Arg sequences is artificially inflated because it ignores the disclosure of claim 5 of Brake 1:

5. A DNA construct comprising a sequence of the following formula:

$\text{L}-(\text{R}-\text{S}-(\text{GAXYCX})_n-\text{Gene}^*)_y$

wherein:

L is a leader sequence recognized by yeast for secretion;

R and S are codons coding for arginine and lysine;

X is any nucleotide;

Y is guanosine or cytosine;

y is an integer of from about 1 to 10;

Gene* is a gene foreign to yeast; and
n is 0 or 1 to 4.

U.S. Application 06/457,325 at 16, ll. 20-32.

In claim 5, spacer R-S encodes four possible sequences (i.e., Lys-Arg, Arg-Arg, Arg-Lys, or Lys-Lys), not 28. Of these four, two permutations, Lys-Arg and Arg-Arg, are within the scope of the count.

Singh cites *Fujikawa v. Wattanasin*, 93 F.3d 1559, 39 USPQ2d 1895 (Fed.Cir. 1996), for the proposition that an application disclosing a generic chemical formula must provide adequate direction to those of ordinary skill in the art to lead them to a subgenus of the proposed count. We find Singh's reliance on *Fujikawa* to be unsound. In *Fujikawa*, we held that disclosure of a generic quinoline structure with four variable groups, each of which could be independently chosen from a list of functional groups, provided insufficient written description support for a count directed to a subgeneric structure having a single combination of the four groups. *Id.* at 1569-71, 39 USPQ2d at 1904-05. However, Brake 1's formula does not present the same issue as did the quinoline in *Fujikawa*. First, replacing a functional group on a chemical compound can often have highly unpredictable results. We noted in *Fujikawa* that even a change as seemingly trivial as replacing an isopropyl group with the isosteric cyclopropyl group at issue in that case could result in either a significant improvement or reduction in the activity of the compound against a particular biological target. *Id.* In the present case, on the other hand, as mentioned above, there are only two subgenera that are biologically relevant: one in which a DPAP signal is present (i.e., $n = 1$ to 4), and one in which it is not (i.e., $n = 0$), a simpler case than in *Fujikawa*. Here, moreover, claim 5 of Brake 1 discloses that "n is 0 or 1 to 4," which is a clear "blaze mark" providing *in ipso verbis* support for "n = 0" in the count. *In re Ruschig*, 54 C.C.P.A. 1551, 379 F.2d 990, 994-95, 154 USPQ 118, 122 (CCPA 1967).

The Supreme Court has explained that "the possibility of drawing two inconsistent conclusions from the evidence does not prevent an administrative agency's finding from being supported by substantial evidence." *In re Gartside*, 203 F.3d at 1312,

53 USPQ2d at 1773 (citing *Consolo v. Federal Maritime Comm'n*, 383 U.S. 607, 620, 86 S.Ct. 1018, 16 L.Ed.2d 131 (1966)). In *Fujikawa*, we said that “[w]hile Fujikawa’s arguments are not without merit, we cannot say, on this record, that the Board’s decision was clearly erroneous.” 93 F.3d at 1571, 39 USPQ2d at 1905. In view of the fact that the “substantial evidence” standard of review that we now use post-*Zurko* requires us to give decisions of the Board greater deference than we gave in cases such as *Fujikawa*, we likewise decline to find legal error in the Board’s conclusion on the record in the present case.

Singh’s reliance on *Bigham v. Godtfredsen*, 857 F.2d 1415, 8 USPQ2d 1266 (Fed. Cir.1988), is also unavailing. In *Bigham*, Godtfredsen’s first application disclosed a compound having a substituent “X”, where X was defined as “a halogen atom.” The application provided as its only example a compound in which X was chloro. *Id.* at 1416, 857 F.2d 1415, 8 USPQ2d at 1267. This court ruled that that application’s disclosure of “halogen” did not meet the requirements of § 112 as a written description of bromo or iodo species, particularly where Godtfredsen had earlier argued in the same case that bromo and iodo were patentably distinct from chloro in order to urge bifurcation of the count. *Id.* at 1417, 857 F.2d 1415, 8 USPQ2d at 1268. In the present case, in contrast, “n = 0” was disclosed in Brake 1. If Godtfredsen had provided examples of fluoro, bromo, and iodo compounds in addition to the chloro compound, that case might have been decided differently, even in spite of Godtfredsen’s “patentably distinct” argument.

[11, 12] Singh’s arguments with respect to enablement are likewise unconvincing. Enablement is a question of law based on underlying factual determinations. *In re Swartz*, 232 F.3d 862, 863, 56 USPQ2d 1703, 1704 (Fed.Cir.2000). We

review the Board’s underlying findings of fact for substantial evidence, and review *de novo* its ultimate conclusion whether a disclosure is enabling. *Id.* Singh argues in his brief:

The Board takes internally inconsistent positions with respect to whether methods for obtaining a construct of the Count using Brake’s starting material were available to those of ordinary skill in the art at the time the Brake 1 Application was filed. To support its finding that Brake is entitled to benefit, the Board finds that such methods existed. However, to support its finding that Singh had not conceived of the invention prior to the Brake 1 Application filing date, the Board makes the contrary finding.

We find no error or inconsistency in the Board’s analysis. As we wrote in *Glaxo Inc. v. Novopharm Ltd.*, 52 F.3d 1043, 1050, 34 USPQ2d 1565, 1569 (Fed.Cir. 1995), “the enablement requirement ... looks to the objective knowledge of one of ordinary skill in the art.” *Id.* (citing *Spectra-Physics, Inc. v. Coherent, Inc.*, 827 F.2d 1524, 1532, 3 USPQ2d 1737, 1742 (Fed.Cir.1987)). Thus, whereas the test for determining whether or not Singh conceived the construct of the count depended on Singh’s own personal knowledge of methods for making the construct and his formulation of a definite and permanent idea therefor, whether Brake 1 enables an invention within the count does not depend on what Brake knew, but rather on whether the application enables one skilled in the art to make and use the invention, *Hybritech Inc. v. Monoclonal Antibodies, Inc.*, 802 F.2d 1367, 1384, 231 USPQ 81, 94 (Fed.Cir.1986), “at the time the patent application was filed.” *Ajinomoto Co. v. Archer-Daniels-Midland Co.*, 228 F.3d 1338, 1345, 56 USPQ2d 1332, 1337 (Fed.Cir.2000). The Board found that the testimony of Brake’s witness, Dr.

Patricia Tekamp-Olson, demonstrated that n in the $n = 0$ construct.⁶ Similarly, those of ordinary skill in the art had in fact that the $n = 0$ construct might have had after-discovered advantages over the $n > 0$ constructs has no bearing at all on whether or not Brake 1 contained an enabling disclosure.

use the " $n = 0$ " construct, including that directed mutagenesis. *Brock v. Falkinham*, 199 at 24-27. The Boardings of the Singh's expert, Dr. Singh relied in his mischaracterization of Tekamp-Olson's testimony. Fritz article.

attempt "proof" that Brake 1 does not tie an enabling disclosure of the invention of the Count, Singh also alleges, for example, that "the Brake 1 Application actually steers the artisan to species clearly outside the Count," that "during prosecution of the Brake 2 Application, Brake argued that the results obtained with the $n = 0$ construct were unexpected," and that "Dr. Brake did not realize the disadvantages of the $n > 0$ constructs until well after the Brake 1 Application was filed." We are not persuaded by any of these arguments, and conclude that Singh has apparently confused the criteria for proving obviousness with those for demonstrating that a disclosure is nonenabling. Although the questions (1) whether or not a reference "teaches away" from a claimed invention and (2) whether or not a claimed invention provides "unexpected results" are relevant in determining whether or not a claimed invention would have been obvious, *W.L. Gore & Assocs., Inc. v. Garlock, Inc.*, 721 F.2d 1540, 1550, 220 USPQ 303, 311 (Fed.Cir.1983), they are not the primary questions bearing on enablement. The fact that the Brake patent states that

We thus conclude that substantial evidence supports the Board's finding that Brake was entitled to the benefit of the Brake 1 application. We have considered Singh's other arguments and do not find them persuasive.

CONCLUSION

Because the Board's decision was supported by substantial evidence and contained no errors of law, the Board did not err in concluding that Singh failed to show (1) that Brake was not entitled to the Brake 1 filing date and (2) that Singh reduced the invention to practice before Brake's priority date. The Board's decision to award judgment to Brake is therefore

AFFIRMED.



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6. The Board properly discredited Falkinham's testimony on that point. Paragraph 9 of Falkinham's Declaration states: "Although there was a theoretical presentation of the $n=0$ construct in the Brake 1 application, there was a clear statement that ' n ' in the construct was 'preferably 2 or 3' (column 3, line 25) or 'usually 2 or 3' (column 2, line 68) ... One

skilled in the art would have determined from the Brake specification that the $n=0$ construct was not desirable." As the Board noted, *Brake*, Paper No. 199 at 36, Falkinham's citations to "columns" 2 and 3 obviously refer to the Brake patent (of which claim 1 is identical to the Count in this interference), and not to Brake 1.